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Memo

DATE: *April 14, 2006*

TO: RHIC E-Coolers

FROM: *Ady Hershcovitch*

SUBJECT: **Minutes of the April 14, 2006 Meeting**

Present: Rama Calaga, Peter Cameron, Xiangyun Chang, Alexei Fedotov, Harald Hahn, Lee Hammons, Ady Hershcovitch, Vladimir Litvinenko, Derek Lowenstein, William Mackay, Thomas Roser, Alessandro Ruggiero, Dejan Trbojevic, Gang Wang.

Topics discussed: Cooling 250 GeV Protons

Cooling 250 GeV Protons: during the last meeting Alexei gave a presentation on electron beam cooling of protons, using 5 nC electron bunches with 4 micron normalized rms emittance. In that presentation Alexei explored 4 cooling scenarios. The examined options were cooling 110 & 250 GeV with and without pre-cooling at 25 GeV (Cooling of 250 GeV protons requires 137 MeV electrons).

Results presented at that meeting showed that in direct cooling of 250 GeV protons results in reducing bunch lengths (for h-360) from about 140 cm to 70 cm which is too long for the PHENIX experiments. Alexei also showed that for h-2520 15 cm long bunches have IBS that is too strong for cooling of 250 GeV protons. However if initial rms bunch length is increased to 29cm, as suggested by Ilan, the use of cooling with h-2520 seems to be feasible.

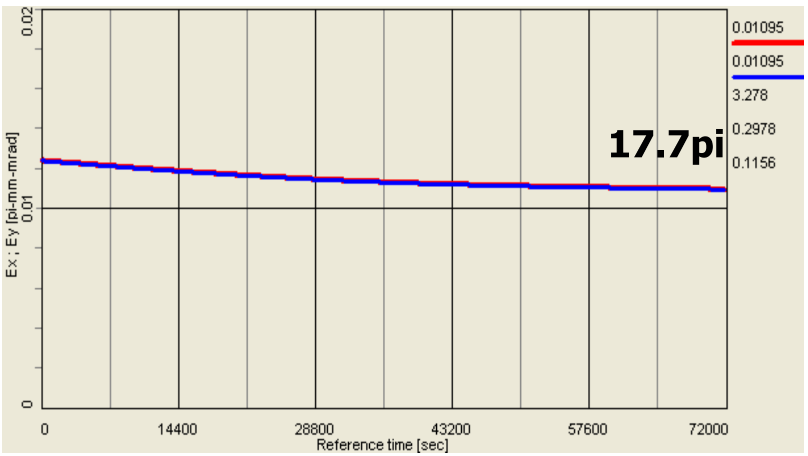
To summarize Alexei's latest results: direct cooling at energy of 110 GeV gives relatively good results, but best performance requires both pre-cooling at low-energy and cooling at 110 GeV. However, for 250 GeV protons, best performance requires both pre-cooling at injection energy and cooling at top energy. With h=2520 and rms bunch length of 29 cm, bunch length can be kept at this value, with marginal growth of emittance in 10 hours. In the h=360 case, practically no growth of emittance but it takes long time to cool bunch length to a reasonable level.

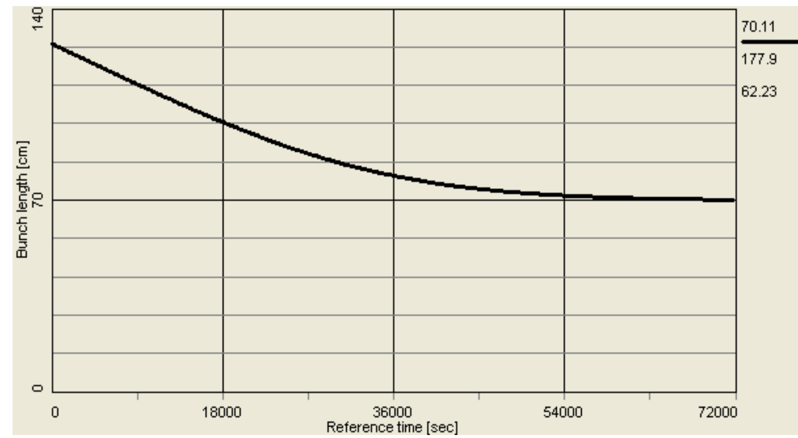
A discussion ensued regarding inclusion of 250 GeV proton cooling in RHIC II. The consensus to include it as a separate cost item, since it is promising enough and the physics at 250 GeV is equally important. Below is Alexei's presentation.

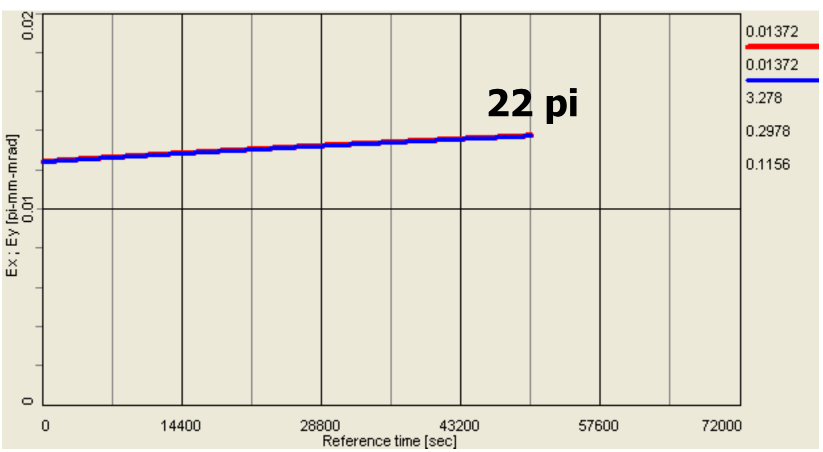
RHIC-II cooling of protons
cooling at 250 GeV

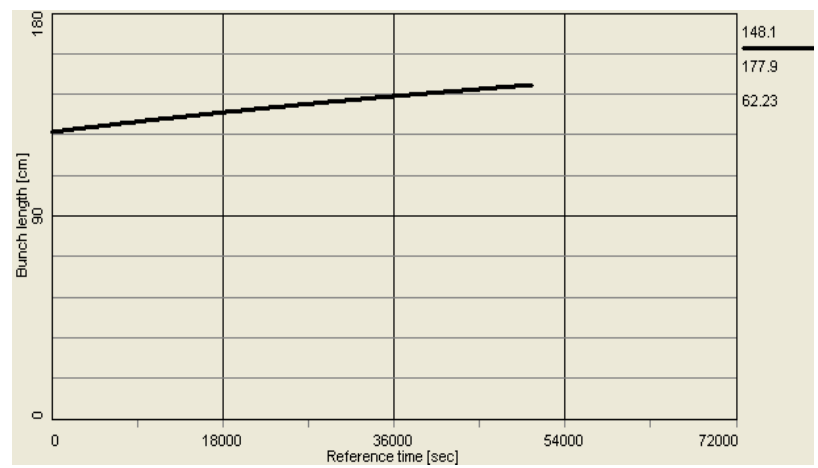
(April 14, 2006)

RHIC-II (N=2e11), NO pre-cooling at injection; Direct cooling of protons at 250 GeV (h=360) needs e-cooler for 137 MeV; Q=5nC, ε_e=4 μm, ε_i=20 π (95%)

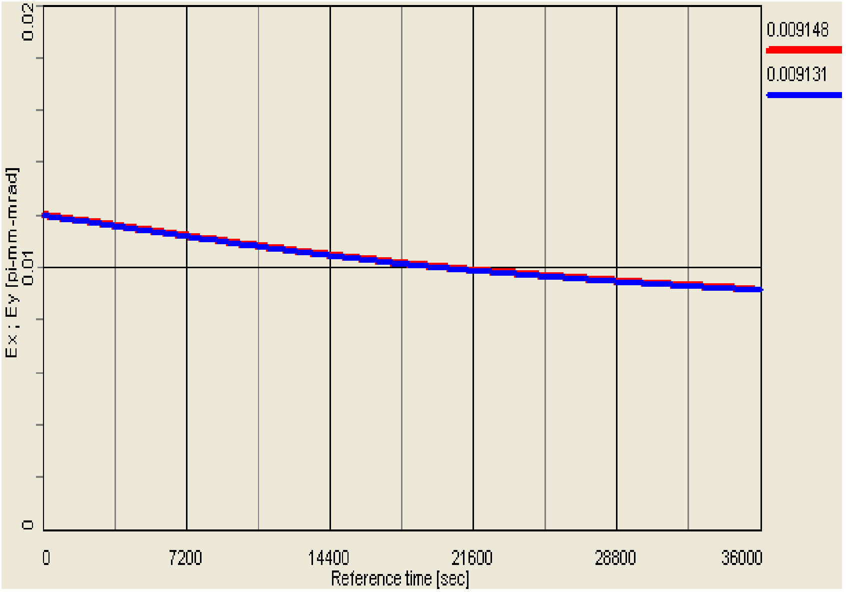


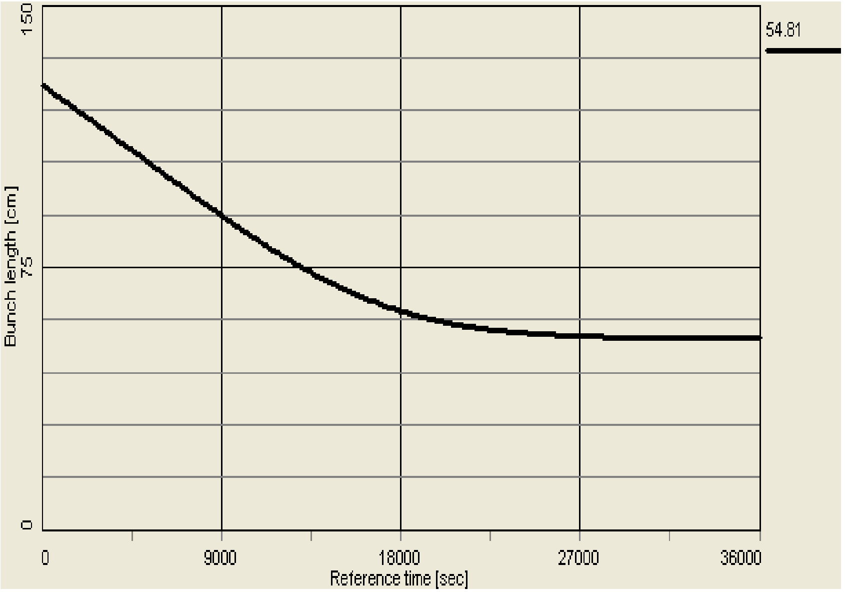






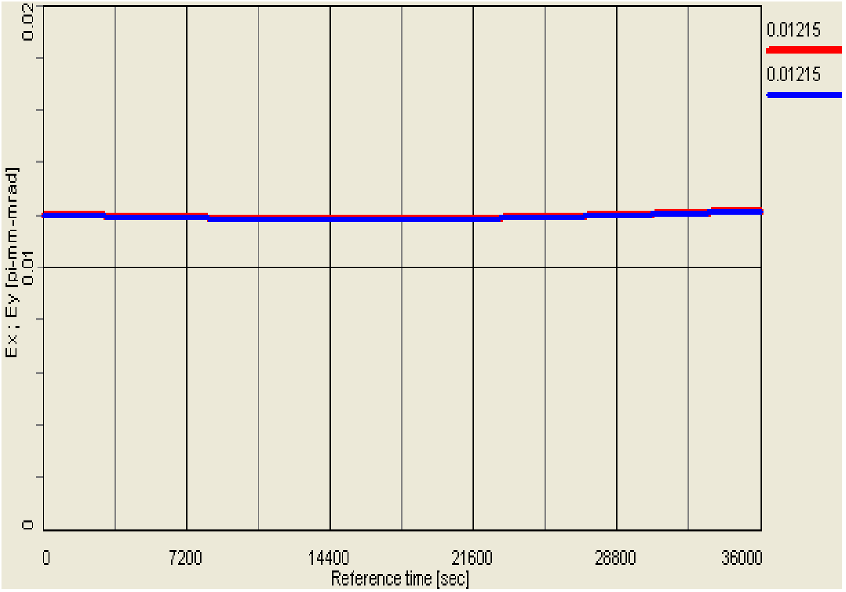
ε_i=20 π (95%)
Q=10nC, ε_e=4 μm, Direct cooling at 250 GeV

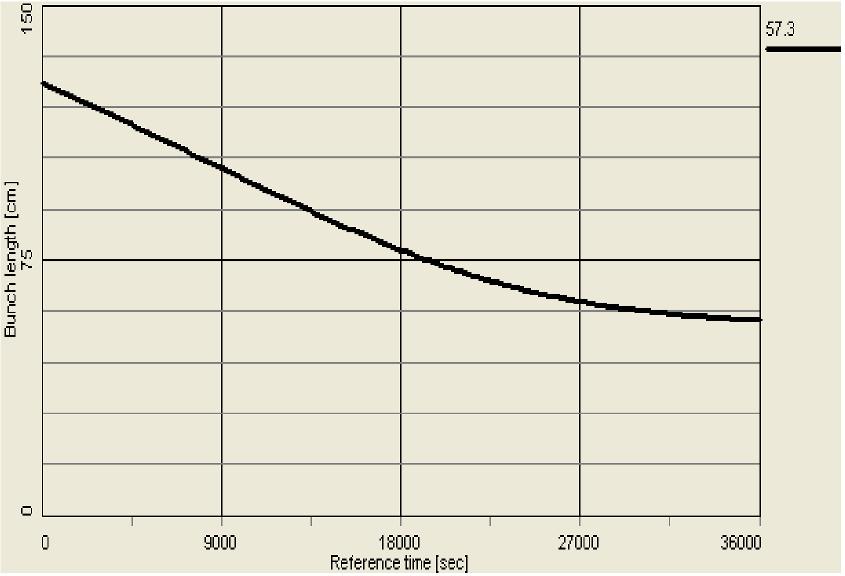




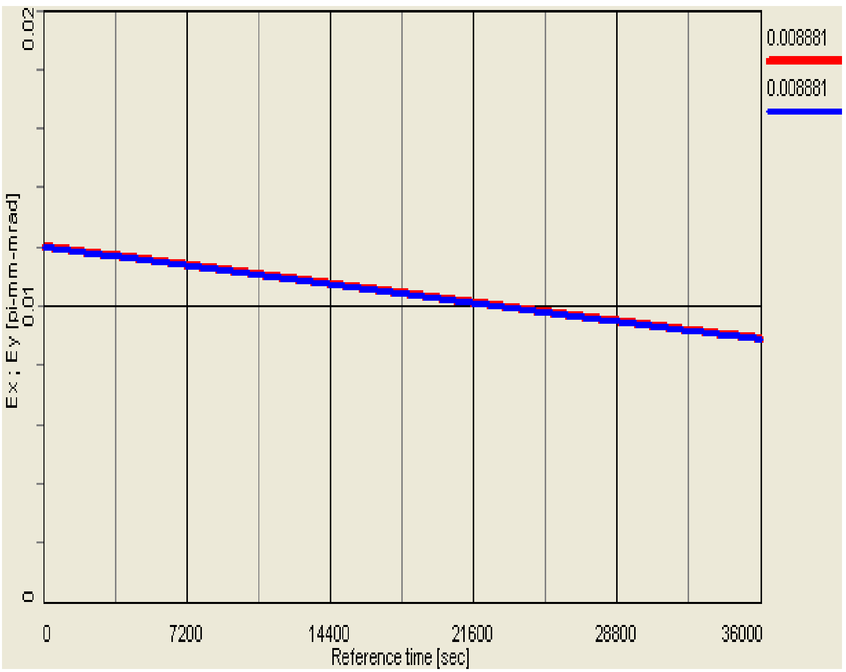
To get advantage of higher charge one also needs to maintain very low emittance

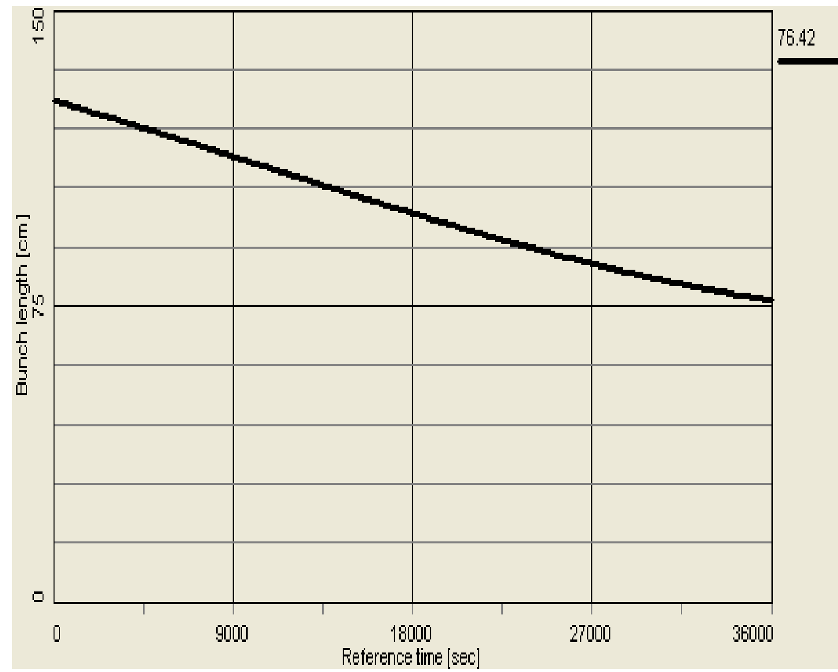
ε_i=20 π (95%)
Q=10nC, ε_e=8 μm, Direct cooling at 250 GeV





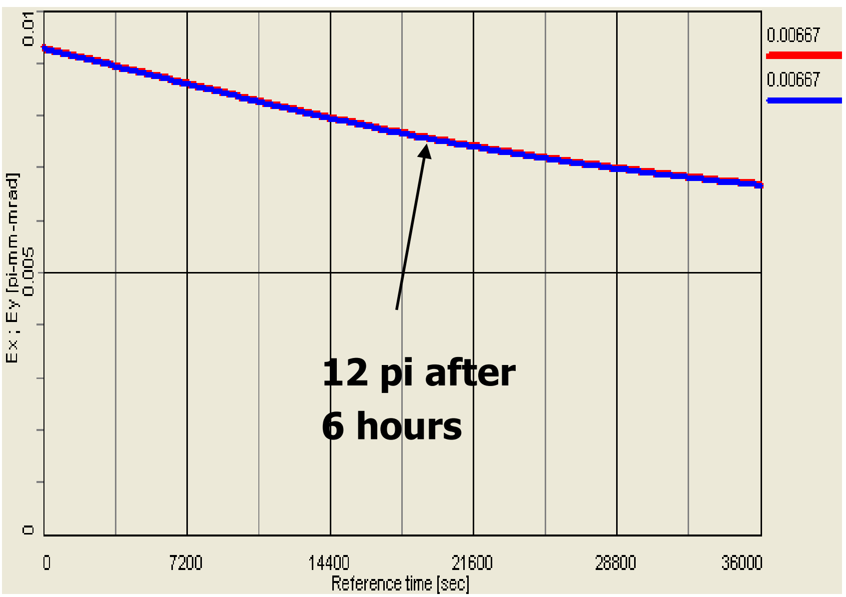
ε_i=20 π (95%)
Q=5nC, ε_e=2 μm, Direct cooling at 250 GeV

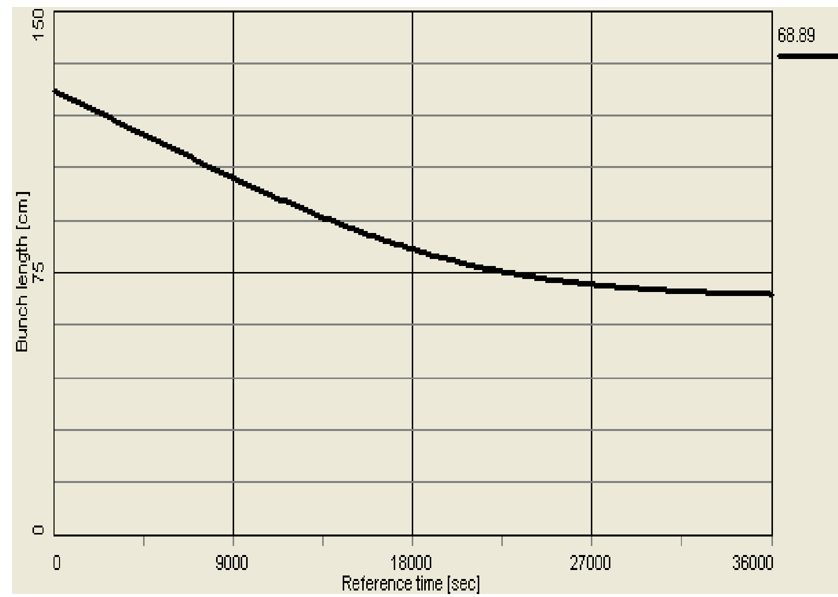




It could be easier to get smaller emittance for smaller charge

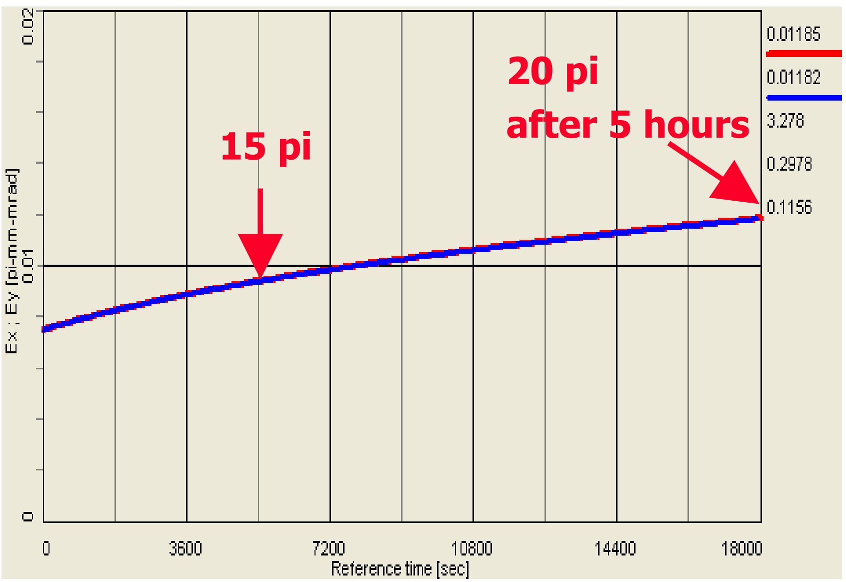
ε_i=15 π (95%)
Q=5nC, ε_e=2 μm, Direct cooling at 250 GeV

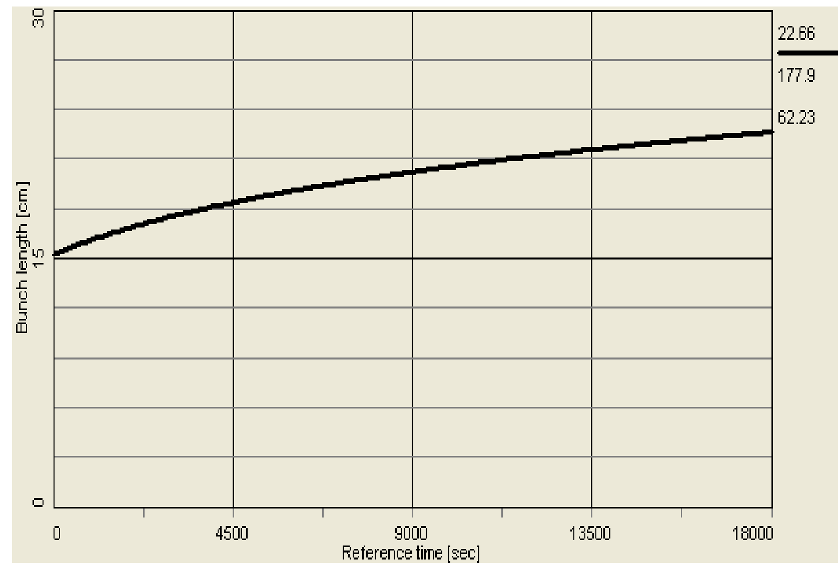




Assuming initial protons emittance for 2e11 will be 15 pi

RHIC-II at 250 GeV with pre-cooling at injection to 12 pi emittance, h=2520 (initial rms bunch length 15 cm) IBS growth (no cooling)

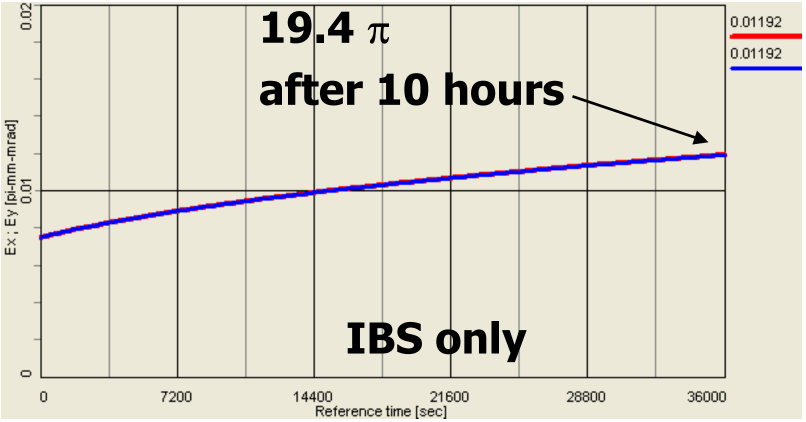


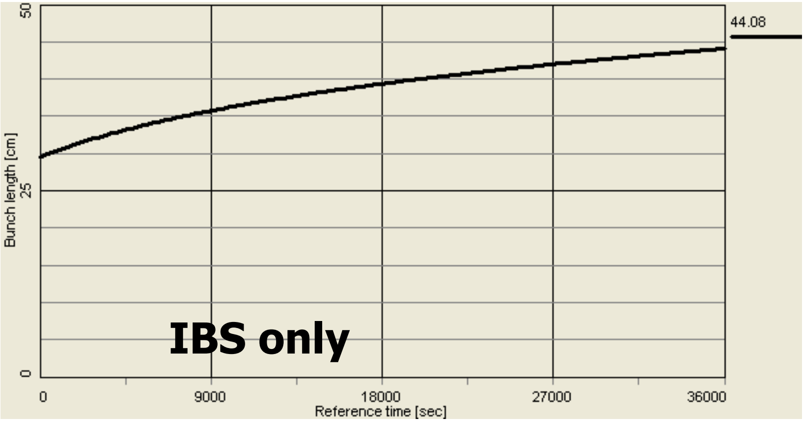


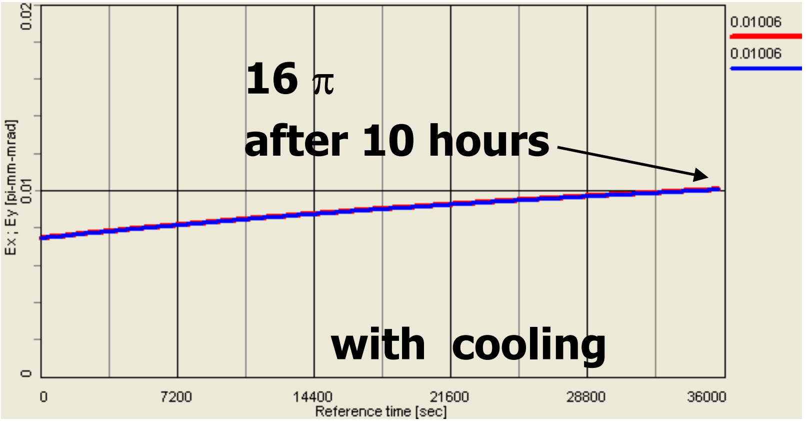
Initial growth rates are large but since both longitudinal and transverse emittance increase rate goes down: one gets factor 1.7 and 1.5 increase for transverse emittance and bunch length in 5 hours, respectively.

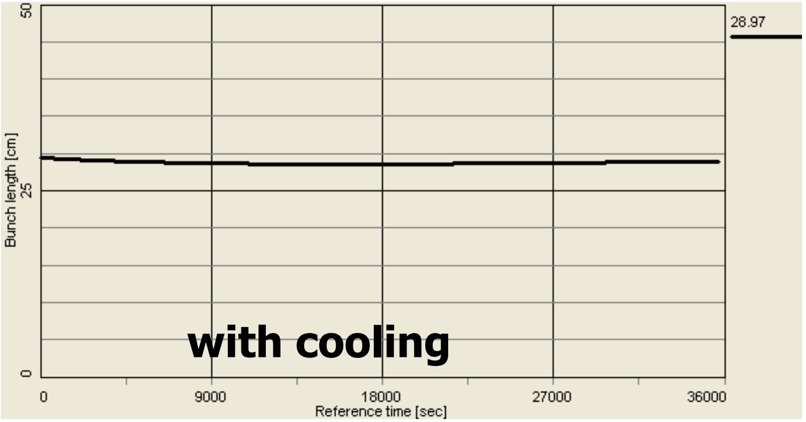
But one needs to get such low (12 pi instead of present 20 pi) initial emittances first – pre-cooling at RHIC or AGS injection ?

Pre-cooling to 12 π at low-energy.
At 250 GeV: h=2520, but initial rms bunch length of protons is 29 cm (instead of 15 cm)

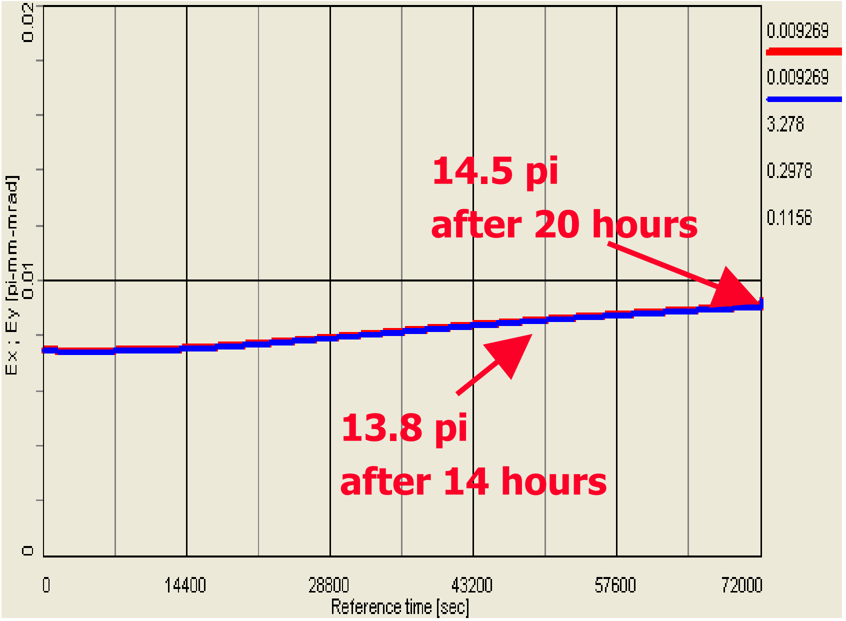


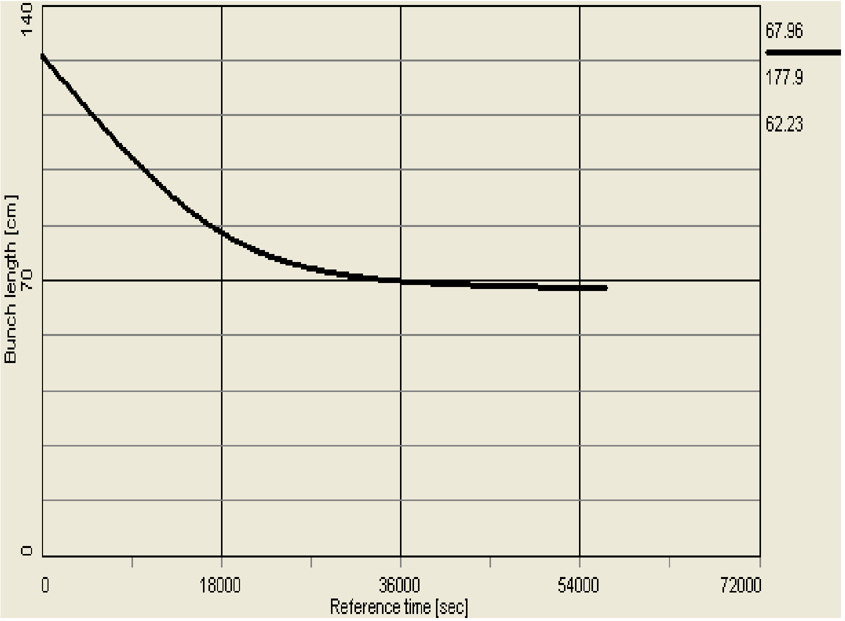






RHIC-II at 250 GeV with pre-cooling at injection IBS plus Cooling for h=360





Requires both pre-cooling at low energy and cooling with 137 MeV electrons

Summary

250 GeV:

- **Best performance requires both pre-cooling at low energy and cooling at top energy.**

2. **With h=2520 and rms length 29 cm – bunch length can be kept at this value. Marginal growth of emittance in 10 hours.**
3. **With h=360 – practically no growth of emittance but bunch it takes long time to cool bunch length.**

110GeV:

- **Best performance requires both pre-cooling at low-energy and cooling at top energy**
- **Direct cooling at top energy gives already good results.**